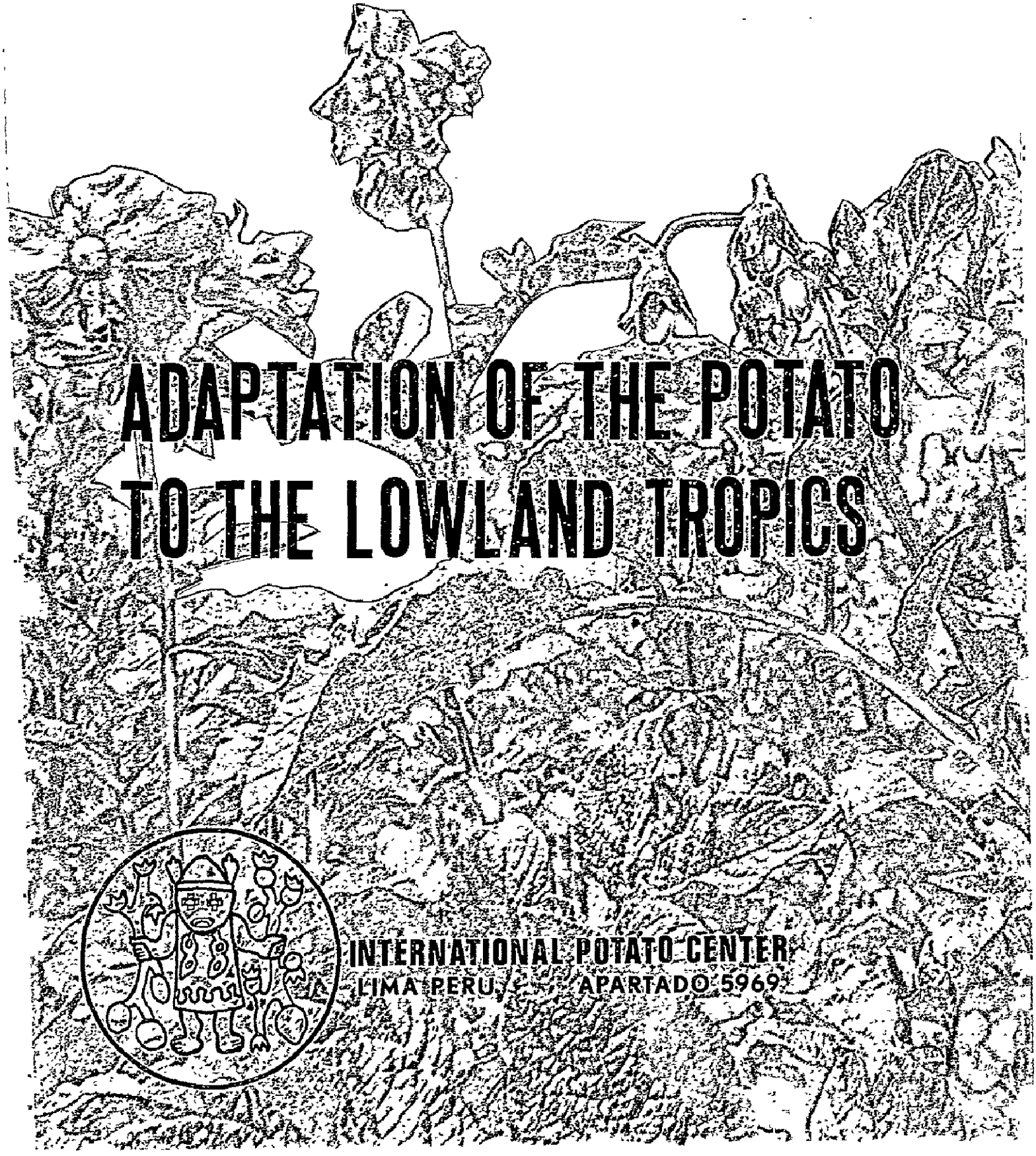
Planning Conference



ADAPTATION OF THE POTATO TO THE LOWLAND TROPICS

INTERNATIONAL POTATO CENTER
LIMA PERU APARTADO 5969

REPORT OF THE

INTERNATIONAL POTATO CENTER

PLANNING CONFERENCE

ON

ADAPTATION OF THE POTATO

TO THE

LOWLAND TROPICS

Held in association with the
Sixth Triennial Conference
of the European Association
for Potato Research,
Wageningen, The Netherlands

September, 1975

C O N T E N T S

F O R E W O R D

NINTH PROGRAM PLANNING CONFERENCE

The International Potato Center (CIP) is a scientific institution autonomous and non-profit making, established by means of an agreement with the Government of Peru with the purpose of developing and disseminating knowledge for greater utilization of the potato as a basic food.

International funding sources for technical assistance in agriculture are financing the Center.

During the past three years CIP has invited 63 experts from 20 countries to attend Planning Conferences to assist in developing five-year plans of research within specific research thrusts or goals. CIP has previously sponsored eight International Planning Conferences. The general Conference strategy has been to utilize the available expertise to help structure CIP's research activities.

The participants at a Conference have a mandate to develop a plan of action, including the identification of priorities. The plan must have a satisfactory balance of research activities between those requiring a long-term effort before breakthroughs can be anticipated and those requiring a shorter term before a desired result can be expected. Five year plans for CIP activities take into consideration research being done or planned at other institutions.

The eight previous Conferences have been concerned with individual research components. This ninth Conference, being held in association with the sixth Triennial EAPR Conference, is the first integrated component Conference - "Adaptation of the Potato to the Lowland Tropics". Of the many possible components which might be considered it has been decided to concentrate on resistance to organisms causing bacterial wilt (*Pseudomonas solanacearum)* and late blight *(Phytophthora infestans)* as well as the physiological adaptation to tropical environments.

O. T. Page

September, 1975

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INTRODUCTION

The Planning Conference on Adaptation of the Potato to the Lowland Tropics had several objectives, the principal being to review current knowledge in three areas of research and to formulate recommendations for future CIP action. Two research areas which are of concern to growing potatoes in the tropics, bacterial wilt *(Pseudomonas solanacearum)* and late blight *(Phytophthora infestans)*, were the subject of Planning Conferences held in December 1972 and August 1973, respectively. The third area, physiological adaptation of the potato to tropical environments, represents a research area about which relatively little is known.

In addition to the specific objectives of the CIP Planning Conference, the opportunity to meet in affiliation with the European Association for Potato Research offered several advantages. Firstly, it permitted CIP scientists to become more familiar with European potato research. Secondly, the EAPR Conference provided a forum to familiarize European potato specialists with CIP's program. Finally, the EAPR Conference offered an excellent opportunity to convene a CIP Planning Conference with busy expert participants already assembled.

Regretably the agenda format made it difficult to record concurrent discussions on the several Conference components. While the recommendations that are presented in this Report were discussed in detail and concisely formulated, considerable background information has been omitted. In an attempt to improve the value of this Report a Section on Integrated Assessment has been included. In this Section recommendations from two previous Planning Conferences, CIP research progress, and the Wageningen recommendations are combined and analyzed.

RECOMMENDATIONS

Late Blight Research

1. Continue to breed for field resistance against *P. infestans*. No specific breeding for "R" genes will be conducted.

2. Investigate the influence of environment on the expression of field resistance with special reference to such factors as daylength, light intensity and temperature under field and controlled conditions.

3. Investigate the presence of "environmental" biotypes and their potential impact on resistance expression.

4. Develop a series of standards for field resistance to be used under tropical lowland conditions. When possible day-length insensitive clones should be used.

   The following varieties have been suggested:

Bintje	Ackersegen	Montserrate
Alpha	Libertas	
Voran	Eigenheimer	

5. Evaluate disease according to a percentage scale and prepare a scheme on how to use the scale.

6. Continue to evaluate components of resistance in advanced breeding material.

Bacterial Wilt

1. Determine whether races and strains of *Pseudomonas solanacearum* of a region are pathogenic on known resistant varieties.

2. Investigate the role of root-knot nematodes in the incidence of wilt; test the wilt susceptibility of nematode resistance clones.

3. Assemble all known sources of resistance to bacterial wilt and screen the CIP collection of cultivated *Solanum* for additional sources of resistance.

4. Promote, and provide or develop the methodology for the following activities by national potato programs:

   a) Detection of *P. solanacearum* in seed lots by either antibody staining procedures or growth of tuber samples under warm conditions optimum for symptom expression.

   b) Research on the value of crop rotation and fallowing and other cultural methods to control bacterial wilt.

   c) Surveys to determine the losses resulting from the incidence of bacterial wilt and the relation of incidence to cause (seed source, previous cropping).

5. It is felt that the bacteria that may pose an equal or greater difficulty to the adaptation of the potato to warmer climates are *Erwinia* species during storage.

Physiological adaptation

1. Screening of segregating populations for adaptation to high temperatures should be under conditions of high night temperatures (min. of 22°C) and with daytime temperatures of 30°C or more. This screening should be done under daylengths of approximately 12 hours.

2. Screening should be done to identify genotypes with the capacity to initiate tubers early under high temperatures and give an early yield.

3. Research on adaptation to moisture stress should be concerned with "low levels of soil moisture or rainfall as well as high levels". Cultural techniques to conserve moisture should be explored.

4. Studies of various temperature regimes with the view of developing more efficient selection methods for heat tolerance should be initiated.

A G E N D A

INAUGURAL SESSION

Friday afternoon, September 12

14:00	Introduction of Participants
	"Overview of the Objectives of the Ninth CIP Planning Conference" Dr. R.L. Sawyer, Director General
	Participants will adjourn to convene in three separate meetings
	I CONTROL OF BACTERIAL WILT
	Participants: Drs. French, González, Plaisted, Jatala
14:30	"Progress in Bacterial Wilt Research" Dr. E. French
15:15	Break
15:30	DISCUSSION: CIP's and other associated research on bacterial wilt Moderator - Dr. E. French
16:30-18:00	Formulation of recommendations for bacterial wilt research
	II PHYSIOLOGICAL ADAPTATION
	Participants: Drs. Sayre, van der Zaag, Rowe, Hermsen, Nganga, Burton, Howard, Opeña, Caesar
14:30	"Development of Potatoes for the Lowland Tropics" Dr. K. Sayre

15:15	Break	
15:30	"AVRDC Potato Screening Program for Heat Tolerance" Dr. R.T. Opeña	
16:00-18:00	DISCUSSION: Physiological factors involved in adapting potatoes to the lowland tropics-recommendations Moderator: Dr. P.R. Rowe	

Saturday morning, September 13

Presentation of recommendations for single component research

09:30	I	Control of Bacterial Wilt Dr. E. French
10:00	Break	
10:15	II	Control of Late Blight Dr. L. Turkensteen
10:45	III	Evaluating Physiological Adaptation to the Lowland Tropics Dr. K. Sayre
11:15-12:15	DISCUSSION: General recommendations for integrated research Moderator: Dr. O.T. Page	

OPEN PLENARY SESSION IN COLLABORATION

WITH EAPR

Friday afternoon, September 19

Theme:	"Adaptation of the Potato to the Lowland Tropics"
Chairman:	Prof. Dr. E.R. Keller
14:30	"Potatoes for the Lowland Tropics" Dr. R.L. Sawyer, Director General
15:15	Break
15:45	Brief review of recommendations and research priorities for single component research Dr. O.T. Page
16:00-17:30	DISCUSSION: Long range planning for integrated research: Wilt-Blight-Physiological Adaptation

Monday, September 22

09:00 DISCUSSION: Climatological and Biological Factors for Potato Production in the Lowland Tropics

1. Definition of Lowland Tropics
2. Daylength range
3. Night vs. day temperatures
4. Rainfall distribution
5. Other parameters

10:30	Break	
10:45	6.	Races of *Pseudomonas solanacearum*
	7.	Tolerance vs. resistance to *P. solanacearum*
	8.	Field resistance to *Phytophthora infestans*
	9.	Host range of resistance to *P. infestans*
	10.	Combined blight-wilt resistance
	Moderator: Dr. E. French	
12:30	Lunch	
13:30-16:30	Formulation of recommendations and priorities for guidance of CIP's integrated program to develop potatoes adapted to the Lowland Tropics	
	Moderator: Dr. O.T. Page	

Background Information

BACKGROUND INFORMATION

I Bacterial Wilt *(Pseudomonas solanacearum)*

A program to evaluate Tuberosum clones for resistance to *P. solanacearum* was conducted at North Carolina State University by F. Haynes and L.W. Nielsen from 1947 to 1960. Nearly 9,000 clones were tested but only moderate levels of tolerance were found. Resistance was discovered by Thurston and Lozano among the *Phureja* in the Colección Central Colombiana. With these stocks a program was initiated in 1967 by P.R. Rowe and L. Sequeira at the University of Wisconsin. Their objectives were to develop germ plasm that would be useful to potato breeding projects in countries where bacterial wilt was a problem, and to investigate the inheritance of resistance. A first series of crosses were made in 1968 with the objective of combining wilt resistance and acceptable horticultural type.

Based on tests conducted in growth chambers, Rowe and Sequeira hypothesized that dominant genes at independent loci conferred resistance. Two virulent isolates, K-60 and S-123 of *P. solanacearum* were used in their extensive tests. The inheritance of resistance to these two isolates was believed to be controlled by two dominant and independent genes for each isolate and by a common gene. Rowe suggested that although the hypothesis should be further tested, it did provide some insight into rational procedures to be used in a breeding program.

Indirect evidence that resistance was rather simply inherited was provided by the impressive number of resistant clones resulting from hybridizing *Phureja* clones with various diploid and tetraploid *Tuberosum*. These "BR" clones were tested by L.C. González in Costa Rica and by E.R. French in Peru, who confirmed the effectiveness of *Phureja* - derived resistance under field conditions.

In December, 1972, a panel of twelve experts from seven countries met in San Jose at the University of Costa Rica to develop a bacterial wilt program for CIP. This was the first Planning Conference sponsored by CIP. In four Sessions bacterial wilt research was reviewed and future problems, objectives, and coordinated research plans were developed for the expanded Wisconsin program now funded through a CIP research contract, and the CIP bacterial wilt project.

A. Priorities of an expanded program

1. The objective of the program has been to provide useful wilt-resistant clones to countries. It was not, necessarily, to supply fully improved and adapted varieties.

2. To find out whether the countries' diverse requirements can be satisfied by just the breeding program carried out in Wisconsin, each country must test extensively a number of advanced clones. This will be the basis for deciding which ones should become varieties or serve as parents for further breeding.

3. In cases where one of the desirable parents for further crosses is strictly a local variety, the breeding will have to be done locally (Colombia, Peru and probably Brazil could do it; Costa Rica, Honduras and Nigeria are not likely to do it).

4. The general guideline for future breeding work recognizes that continuous commercial planting in infested soil is undesirable anywhere; rather, the importance of clean seed and crop rotation as complements to wilt-resistance must be recognized. Moderate levels of resistance are probably adequate for cool potato growing regions.

5. No search for better sources of resistance than the present clones of *S. phureja* is contemplated.

6. There is a need to improve the seedling mass-screening procedure to cope with local needs, as in the particular virulence of the bacterium in Ceylon and Fiji. This "tailor-made" screening can be applied to the seed

from specific crosses.

7. Simultaneous field testing and multiplication do not work. Maintenance and increase should be in wilt-free areas. There is a need for either a seed-multiplication program in each country or regional centers that can supply neighboring countries with commercial amounts of seed.

B. Anticipated role of CIP

1. International coordinator to improve the flow of information and materials.

2. Establishment of regional coordinators through which efforts on Bacterial Wilt could be channeled.

3. Supplemental funding for cooperative projects in instances when a scientist is better able to conduct a specific item of research than can be performed by CIP in Peru, but he has funding limitations.

4. Possibility for multiplication of valuable stocks in double-screened houses in Peru.

5. Sponsorship of technical meetings, such as a short course in plant breeding to induce Bacterial Wilt breeding work by interested scientists trained in other disciplines or crops.

6. Investigations on specific aspects, such as the importance of latent lenticel infections as a masked means of spread of *P. solanacearum* from seed lots.

II. Late Blight *(Phytophthora infestans)*

A Planning Conference on "Late Blight Strategy" was held at CIMMYT, El Batan, Mexico, in August, 1973. A comprehensive report of this Conference was compiled by Dr. E.R. French and published by CIP. The participants at the Conference were: Drs. W. Black, E.R. French, J. Galindo, M.E. Gallegly, J. Guzman, J. Malcolmson, J.C. Mooi, J. Niederhauser, S. Romero, K.D. Sayre, H.D. Thurston, V.R. Umaerus, R. Wurster, and M. Yamamoto.

The status of knowledge of resistance, sources of resistance, breeding methods, the pathogen, and environmental adaptation was reviewed. A program was proposed for CIP based on a detailed consideration of a position paper presented by Dr. V.R. Umaerus and on other facets of background knowledge contributed by the participants.

The proposed program was as follows:

Testing for Blight Resistance at Toluca

The international late blight testing program, that was conducted under auspices of the Rockefeller Foundation during many years, will continue to be carried out by CIP for as long as it provides a service to plant breeders that cannot be fulfilled effectively by more simple, less costly means. The Toluca valley offers the most stringent blight test known in the World, and will be available for final evaluations of selections made by screening at national (and when possible regional) sites. Regional testing sites will be promoted by CIP, and their relative value assessed by comparison with Toluca.

To improve the test, a standardized rating system for late blight evaluation will be developed (or an existing one selected) that incorporates visual aids and essentially follows, the system so far in use at Toluca. Evaluations will be made at approximately weekly intervals from the inception of blight on the standard susceptible (Alpha) until about 2 weeks after it is killed and data on this standard and the resistant standard (Atzimba) will be reported. Also meteorological information for the period will be included. Yield information will not be routinely taken, but may be requested for multiple tuber clone submissions. Additional help to breeders, such as the execution of requested selfing and crossing, will be provided when possible.

Since CIP's objective is to assist the nations of the developing world, all testing done will be upon the conditions that the materials tested can be used by CIP for that purpose.

Maintenance and Development of Resistance Sources

The large collection of resistant clones in the Toluca collections will be reduced in number - these contain mostly *S. demissum* resistance genes. The best clones developed by breeding programs around the world will be added to this collections. Any new sources of resistance found in CIP programs in Peru will be included in the collection; those developed by others will be requested. This collections will be evaluated for as many characteristics as possible so as to be able to make the most suitable clones available according to the needs of each location.

Several combinations of resistance to various diseases and other desirable features will be developed. Resistance genes from species not presently available in the Toluca collection will be incorporated into more desirable clones more readily usable in breeding programs. Different sources of resistance, including tuber resistance, will be combined. Daylength insensitivity genes will be sought and incorporated into desirable resistance sources. True seed of superior crosses, from both mass pollination and controlled cross methods, will be made available. Desirable combinations of resistance to late blight and other diseases or factors will be produced. The glycoalkaloid content will be determined in order to avoid clones with high level for use in breeding programs.

In Peru an attempt will be made to locate highly resistant clones with no major genes, which would reduce the need for testing at a location such as Toluca, and might permit breeding and selection work to be done entirely wherever late blight occurs.

Monitoring Pathogencity

To assess the pathogenicity range of the late blight organism *(Phytophtora infestans)*, two standard differential sets will be established, maintained virus-free and distributed: one for field resistance (polygenic resistance) and another for the major R-genes (monogenic resistance).

The field resistance differential clone set will consist of 5 clones representing the five grades of the rating scale among clones adapted to the short daylength conditions of

Toluca (selected amongst many clones whose ratings have been previously recorded and which will be carefully scored during two growing seasons, and also tested to Race 0 and submitted to qualitative and quantitative inoculation tests) and a similar long daylength set will be selected by North-European scientists (possibly Swedish, Dutch and Scottish).

The major gene differential clone set will consist of the series at Pentlandfield comprising the 12 single gene genotypes r, and R_1 through R_{11} plus additional combinations of these genes that are available. CIP is requesting the Scottish Plant Breeding Station to assume the responsibility of maintaining both clone sets and distributing them on CIP's behalf to interested programs around the World.

Since so much responsibility for the success of the Center's programs depends on the polygenically inherited field resistance it is important to know beyond a doubt whether the fungus can also adapt to this type of resistance as it has to the monogenic resistance. The accumulated data on blight incidence in fungicide sprayed vs. non-sprayed plots at Toluca will be analyzed to determine if it shows that a shift in aggressiveness of the fungus has taken place. This research will be continued utilizing the more precise rating system that will be developed. The field resistance clone set will be included in future tests, and will be rated in other locations around the world for the same purpose. Studies on the repeated passage of an isolate through clones with different levels of field resistance will be encouraged among collaborators or CIP's own staff.

The role of the sexual stage in survival and the epidemiology of disease development will hopefully continue to be studied by the pioneering Mexican scientists, or by visiting scientists with CIP at Toluca. The presence of the compatibility type A^2 will be investigated in Peru, and surveying for it in other South American countries and Central America will be encouraged.

Field Resistance

Studies on the mechanism of field resistance are being conducted through a CIP linkage project at the Swedish Seed Association in Svalov, Sweden under the direction of Dr. Vilhelm

Umaerus. Emphasis is being placed on 1) resistance to entrance by the fungus into the leaf, 2) resistance to growth of the fungus in the leaf and 3) a reliable method for assessing the possible correlation between leaf resistance and tuber resistance. Similarly, studies on the inheritance of the components of field resistance are being initiated at Svalov.

Additional studies on tuber resistance would be desirable. If there is a correlation between foliage resistance and tuber resistance a method of foliage assessment might be developed which reveals the correlation. This could accelerate breeding programs concerned with tuber resistance. Research on the nature of field resistance in the tuber may be needed to bring this about.

Late blight control

Research to control late blight by other means than resistance will be considered, such as the value of high ridges for tuber rot control. The progress in chemical control will be monitored with special interest on the research and development of systemic fungicides.

Adaptation of the potato in relation to blight

The incidence and significance of late blight will be an integral part of CIP research programs on the adaptation to environments beyond its recognized normal range (e.g., lowland tropics). The standard resistance sets will be included at these research sites. Information will be requested from collaborators receiving these sets so as to accumulate information on their response to differing daylength.

III Lowland Tropics

In a generalized sense the "lowland tropics" are characterized by having an elevation of less than 1,000 meters, a mean temperature above 25°C, and rainfall between 1,500 - 5,000 mm per annum. Radiation intensities may commonly exceed 10,000 foot candles. In the lowland tropics maximum daylength varies between 12.1 $\pm$ 1.0 hours at 20° N and 20° S of the equator, the approximate latitude range encompassing the lowland tropics. The maximum photoperiod range at these latitudes is 12.4 $\pm$ 1.4 hours at an intensity of 10 foot

candles (108 lux) and 12.6 ± 2.2 hours at an intensity of 2 foot candles (21.5 lux) when the sun is 3° and 6° below the horizon, respectively. Included in this broad region are parts of Central America, the Amazon and Orinoco River basins in South America, the Congo River basin in Africa, parts of India and Bangladesh, and Southeast Asia.

Clearly, very little is known about growing potatoes in the hot, humid tropics. Typically there are rainy and dry seasons which might influence the timing of growing potatoes. From preliminary studies it appears that Tuberosum x Phureja clones are better adapted that Andigena clones. Nor is it known what climatological genotype interactions govern tuber production under lowland tropical conditions - whether, for example, high night temperatures are a critical factor in inhibiting tuberization in Andigena clones. Of considerable significance is the need for a rapid bench screening procedure to select seedlings with a good potential for adaptation to heat stress in the field.

In addition to selecting clones adapted to heat stress there is a need to incorporate some reasonable level of resistance to disease and pests, particularly after repeated cropping of potatoes in areas where they have heretofore not been grown. At the Yurimaguas location, for example, Choanophora was an important foliage pathogen but late blight was not observed. It is anticipated that root-knot nematodes and bacterial wilt also may be potentially serious in some locations.

Integrated Assessment

INTEGRATED ASSESSMENT

I Bacterial Wilt *(Pseudomonas solanacearum)*

(a) Inheritance of resistance

Initially it was thought that resistance was rather simply inherited since resistance to isolates K-60 and S-123 of *P. solanacearum* appeared to be controlled by two dominant and independent genes for each isolate and by one common gene. This hypothesis was supported by the relatively large number of "BR" clones resulting from crossing *S. phureja* and *S. tuberosum*. Further studies on the inheritance of resistance conducted in Wisconsin has provided additional evidence that the narrow source of resistance being used was isolate specific and not "general". This implies that screening should be done with a mixture of isolates, and/or that a search should be made for a different type of resistance. The Wageningen Planning Conference recommendations # 1 and # 3 refer to this situation.

Preliminary screenhouse studies indicate that infections and wilt development by *P. solanacearum* is enhanced in the presence of the root-knot nematode, *Meloidogyne incognita*, in both wilt resistant and wilt susceptible cultivars. The extent of increased wilt injury in the field as the result of nematode interaction is unknown. Recommendation # 2 refers to the interrelationship between wilt bacteria and root-knot nematodes.

(b) Survival of *P. solanacearum*

The long-term survival of *P. solanacearum* in the soil is doubtful. Results from studies on the survival of a race in northern Peru (Viru valley), where summer temperatures are ideal for wilt development, confirmed that diseased tubers are more important than soil in bringing about high levels of wilt. Survival in 21 cultivated and weed plants indicate that tomato and *Nicotiana glutinosa* can be infected by soil-borne bacteria whereas chilli, chilli pepper, and eggplant are susceptible to stem inoculation. The necessity of studies on crop rotation, fallowing, and clean seed to reduce the

incidence of bacterial wilt is emphasized, Recommendation # 4 (b) and # 4 (c).

(c) Detection of *P. solanacearum*

Improved selective media were reported in CIP's Annual Report, 1974. These antibiotic-containing media permitted the detection of race 3 from artificially infested, fumigated soil at concentrations as low as 2×10^5. The continuing need for an improved rapid screening technique to detect *P. solanacearum* in seed lots is indicated in Recommendation # 4 (a).

(d) Review of Recommendations, 1972 Planning Conference

(i) Seven priorities for an expanded bacterial wilt program were proposed by participants at the Planning Conference on Bacterial Wilt in December, 1972. It was stressed that advanced clones be tested by national programs, unless one of the parents of a desirable cross was a local variety. In this latter instance the breeding would be done in a national program if adequate expertise existed. This recommendation has been generally followed as has the recommendation that useful wilt-resistant clones be provided, but not necessarily fully improved adopted varieties.

In view of the equivocal results obtained in field tests in 1973-75, the 1972 recommendations that no further search for better sources of resistance were intended is voided by the Recommendation # 3 proposed in Wageningen.

The 1972 recommendation to improve mass seedling screening is still a valid proposal, particularly using as broad a range of isolates as possible. The need for a seed-multiplication program in each country, or regional centers that can supply neighboring countries is on going.

(ii) Six recommendations relating to the anticipated role of CIP were also proposed at the 1972 Conference.

(1) The need for an international co-ordinator to improve the flow of information and materials, and, (2) the establishment of regional co-ordinators through which advanced

technology on wilt control could be channeled is now an integral part of CIP's program. (3) The proposal to fund a cooperative project has been fulfilled through an excellent contractual association with the University of Wisconsin. (4) The possibility for multiplication of valuable stocks, which was anticipated in 1972, is well in hand through CIP's clean seed program. (5) Sponsorship of courses to include bacterial wilt breeding work is covered by both short-and longer-term training courses and by graduate research programs. (6) Finally, the recommendation to investigate the importance of latent lenticel infections as a masked means of spread of *P. solanacearum* from seed lots has received little or no attention.

II Late Blight *(Phytophthora infestans)*

The late blight fungus has several reproductive mechanisms with the potential of producing new pathogenic recombinants. One of the mechanisms involves the sexual mating of A_1 and A_2 compatibility types resulting in the formation of oospores which, on germination, produce sporangia. These sexually produced sporangia, as well as asexually produced sporangia, either germinate directly or, more commonly, indirectly to produce motile zoospores. New pathogenic recombinants are detected on host differentials and are classified as races such as: 1; 2; 1.2; 1.2.3;.....11. Host resistance to races is referred to as "major gene" or "R" gene resistance. The frequency with which new races of the fungus have overcome the static genotype of asexually propagated host clones has discouraged further breeding for major gene resistance.

International Late Blight Trials - Toluca

The Toluca Valley of Mexico is recognized as an outstanding test location because the environment favors both the production of pathogenic recombinants of *P. infestans*, as well as the regular occurrence of blight epidemics. CIP continues to offer international late blight testing services at Atizapan in the Toluca Valley, formerly conducted under the auspices of the Rockefeller Foundation.

In response to the recommendations made at the Late Blight Planning Conference in 1973, it is now recommended that a standardized percentage scale of foliar blighting be used.

(Recommendation # 5, 1975 Wageningen Conference). It will continue to be a general requirement that clones submitted for testing in the International Blight Trials will be accompanied by information on the parentage of each clone.

Monitoring Pathogenicity

It is CIP's objective to breed only for "field" or "general" resistance to blight as per 1975 Recommendation # 1. As proposed in 1973, and so far not accomplished, a differential clone set representing gradations in field resistance is to be established. Seven varieties free of "R" genes have now been proposed (Recommendation # 4, 1975). It has also been advised that CIP continue to evaluate components of resistance in advanced breeding material (Recommendation # 6). Many of the advanced clones developed by the Rockefeller Program in Mexico are being evaluated by CIP. Since these clones contain "R" genes it is a continuing recommendation that "R" gene differentials be planted wherever these Mexican clones are being assessed.

Relatively little information is available concerning the influence of the environment on the expression of general resistance under either field on controlled conditions. Recommendations # 2, 1975, refers to the need to investigate environmental influence on field resistance. No special research has yet been undertaken regarding the 1972 recommendation to determine if there is a correlation between the field resistance of foliage and tubers.

The possibility of the existence of "environmental" biotypes of *P. infestans* was discussed at the Wageningen Conference. This concept proposes that through natural selection pathogenic strains of the fungus have become adapted to specific ecological niches and consequently will be more aggressive under those conditions than non-adapted biotypes. Recommendations # 3, 1975, is directed to research to examine this hypothesis.

Recent research has confirmed that the genetic potential exists for adapting the potato to the hot, humid tropics. This potential must now be strengthened and fortified through the addition of resistance to late blight and bacterial wilt.